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TRANSISTOR ANALYZER

MODEL 850

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INSTRUCTION BOOK

FOR

TRANSISTOR ANALYZER MODEL 850

RETURN TO
AEROSPACE DIV.

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THE HICKOK ELECTRICAL INSTRUMENT CO.
10514 Dupont Ave. - Cleveland, Ohio

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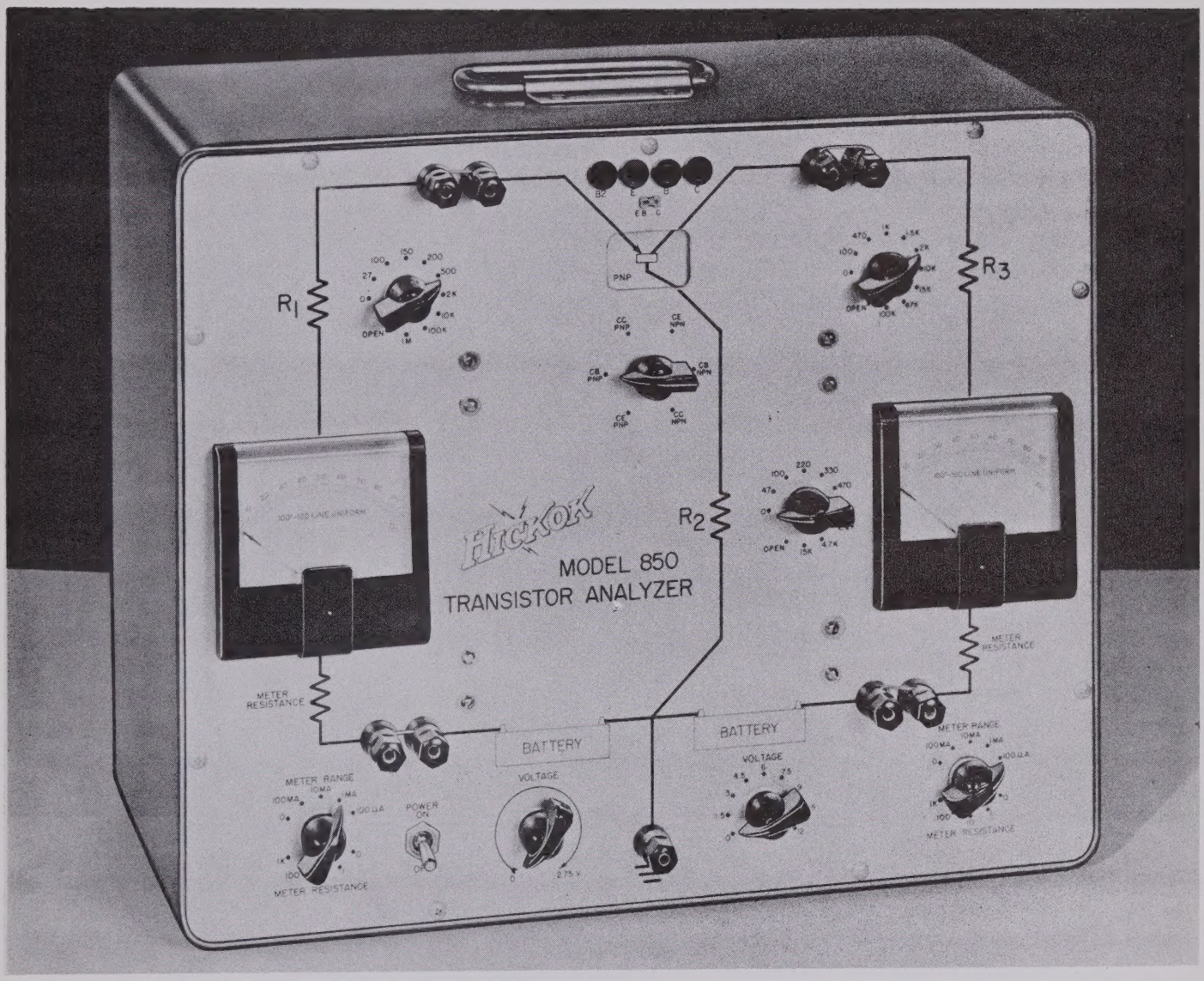


TRANSISTOR ANALYZER

MODEL 850

INSTRUCTION BOOK
FOR
TRANSISTOR ANALYZER MODEL 850

TECHNICAL CHARACTERISTICS

1. Power Requirements:

   8 - 1.5 volt, Size D cells - output circuit supply
   2 - 1.5 volt, Size D cells - input circuit supply

2. Configurations:

   a. COMMON EMITTER, CE, PNP or NPN
   b. COMMON BASE, CB, PNP or NPN
   c. COMMON COLLECTOR, CC, PNP or NPN

3. Variable Input Resistance:

   Zero to 1 megohm in steps

4. Variable Output Resistance:

   Zero to 100K ohms in steps

5. Meter Accuracy - ± 2%

6. Meter Ranges - Input and Output Meters:

   a. 100 Microamperes
   b. 1 Milliampere
   c. 10 Milliamperes
   d. 100 Milliamperes
   e. 1 Ampere

7. Meter Resistance - Input and Output Meters:

   a. 1000 ohms on 100 Microampere range.
   b. 100 ohms on 1 Milliampere range.
   c. 10 ohms on 10 Milliampere range.
   d. 1 ohm on 100 Milliampere range.
   e. .1 ohms on 1 Ampere range.

8. Voltage Supply for input circuit variable 0 to 2.75 Volts with a source resistance of .5 ohms. Provisions for externally applied voltage if necessary.

9. Voltage Supply for output circuit 0 to 12 Volts in 1.5 Volt steps with a Source Resistance of .5 ohms. Provision for externally applied voltage if necessary.

10. POWER ON-OFF switch spring loaded in the normally OFF position to conserve batteries.

11. Meter Protection:

    Meters are protected against overload with silicon diodes.

12. . The TRANSISTOR ANALYZER will measure the following parameters of a transistor:

    a. Beta
    b. Alpha
    c. Input Resistance
    d. Output Resistance
    e. Leakage Ico and Iceo
    f. Power Gain

FUNCTION OF CONTROLS AND BINDING POSTS

Configuration Selector:

This control selects the circuit in which the transistor is to be tested. Common emitter, common base, or common collector, either PNP or NPN. As this selector is switched from one position to another, the dial above it indicates how the transistor is connected in the circuit.

Control R1:

This switch selects the value of resistance R1. The values of resistance are indicated around this control. R1, along with battery voltage E1, determines the amount of current flow in the input circuit.

Control R2:

This switch selects the value of resistance R2. The values of resistance are indicated around this control.

Control R3:

This switch selects the value of resistance R3. The values of resistance are indicated around this control.

VOLTAGE E1 control:

Adjusting this control varies the battery voltage E1 from 0 to 2.75 Volts D.C. The voltage E1, along with any resistance in the input circuit, determines the amount of current flow in the input circuit.

VOLTAGE E2 control:

This switch selects different values of battery voltage E2 in the Output Circuit. This control covers the range of zero to 12 volts D.C. in 1.5 volt steps.

Binding Posts B1:

These binding posts normally have a shorting bar or a jumper wire across them to complete the circuit. The purpose of these binding posts is to provide a check point for the polarity and the voltage of E1. Also, should the need for a greater voltage arise, the jumper can be removed and an external voltage applied between the two binding posts.

Binding Posts B2:

These binding posts have the same function as B1 except that they are located in the output circuit.

Meter range selectors:

The INPUT and OUTPUT METER RANGE Selectors are identical. Their function is to select the desired meter range of the input and output meters respectively. These selectors also indicate meter resistance in the circuit. Depending on the range used, the back side of the knob indicates the series meter resistance in the circuit.

INPUT binding posts:

These are located in the upper left side of the panel. Normally they have a shorting bar or a jumper wire across them to complete the circuit. In breadboard work, for example, if an amplifier using a transistor is set up, the input signal can be injected at this point. The amplified signal can then be taken out from the OUTPUT binding posts.

OUTPUT binding posts:

These have the same function as the INPUT binding posts except that they are located in the output circuit.

If control R1 does not include the desired value of resistance, this control can be set to ZERO and the desired resistance inserted between the input binding posts.

POWER ON-OFF:

This switch is spring loaded to the OFF position. To operate the instrument, the switch handle is depressed and held down until the transistor check is completed, then released to turn off the instrument. This feature is incorporated to conserve battery power.

Input meter:

This meter is located on the left side of the instrument and measures D. C. current flow in the input circuit. The INPUT METER RANGE selector is used in conjunction with this meter. The meter scale has 100 divisions and is used directly on the 100 microampere and 100 milliampere ranges. On the 1 milliampere and 1 ampere range it is necessary to divide the reading by 100. On the 10 milliampere range the reading is divided by 10.

Output meter:

The output meter is located on the right side of the instrument. Its function is the same as the input meter except that it is used in the output circuit.

PURPOSE

The Hickok Model 850 TRANSISTOR ANALYZER has been designed primarily to enable the Radio-TV technician to check transistors simply and accurately.

With the help of the test circuit inscribed on the front panel the technician, in checking a transistor, becomes familiar with the operation of transistors.

After checking transistors for a while, the technician will become sufficiently familiar with transistor theory to use the TRANSISTOR ANALYZER as a breadboard to build up transistor amplifiers, oscillators, etc.

The TRANSISTOR ANALYZER is also intended for laboratory use. Transistors can be tested under any conditions that are necessary in the laboratory. Engineers can use this instrument to design transistor circuitry; it lends itself to this application because all parameters are variable.

This instrument also has a place in schools. It is excellent for the training of students in transistor theory and application. With the basic circuitry automatically set up by the TRANSISTOR ANALYZER, laboratory experiments are performed simply and quickly.

BRIEF DESCRIPTION

The Model 850 TRANSISTOR ANALYZER consists of six basic circuits for transistor testing. The various circuits are selected by switching of the configuration selector. The basic circuits are shown in Figure 1.

An interesting observation to be made from figure 1 is that the only difference between the NPN and PNP configurations is the battery polarity. This is normal--NPN transistors require battery polarities opposite to those of PNP transistors.

Each configuration will be briefly described with reference to its application to transistor testing.

COMMON EMITTER·

The COMMON EMITTER circuit of Figure 1-A or 1-D is used to measure Beta and Iceo. Beta is regarded as the current amplification factor of a transistor. AC Beta is the ratio of the change of collector current to a small change in base current with constant collector voltage. DC Beta is defined as the base current divided into the collector current or Ic/I_b. For example, referring to Figure 2, one Milliampere of current flowing in the base or input circuit causes a collector current of 50 Milliamperes. This yields a DC Beta of 50, neglecting the collector leakage current which is small. The difference between AC Beta and DC Beta is small, particularly when AC Beta is checked at a low frequency and under typical operating conditions.

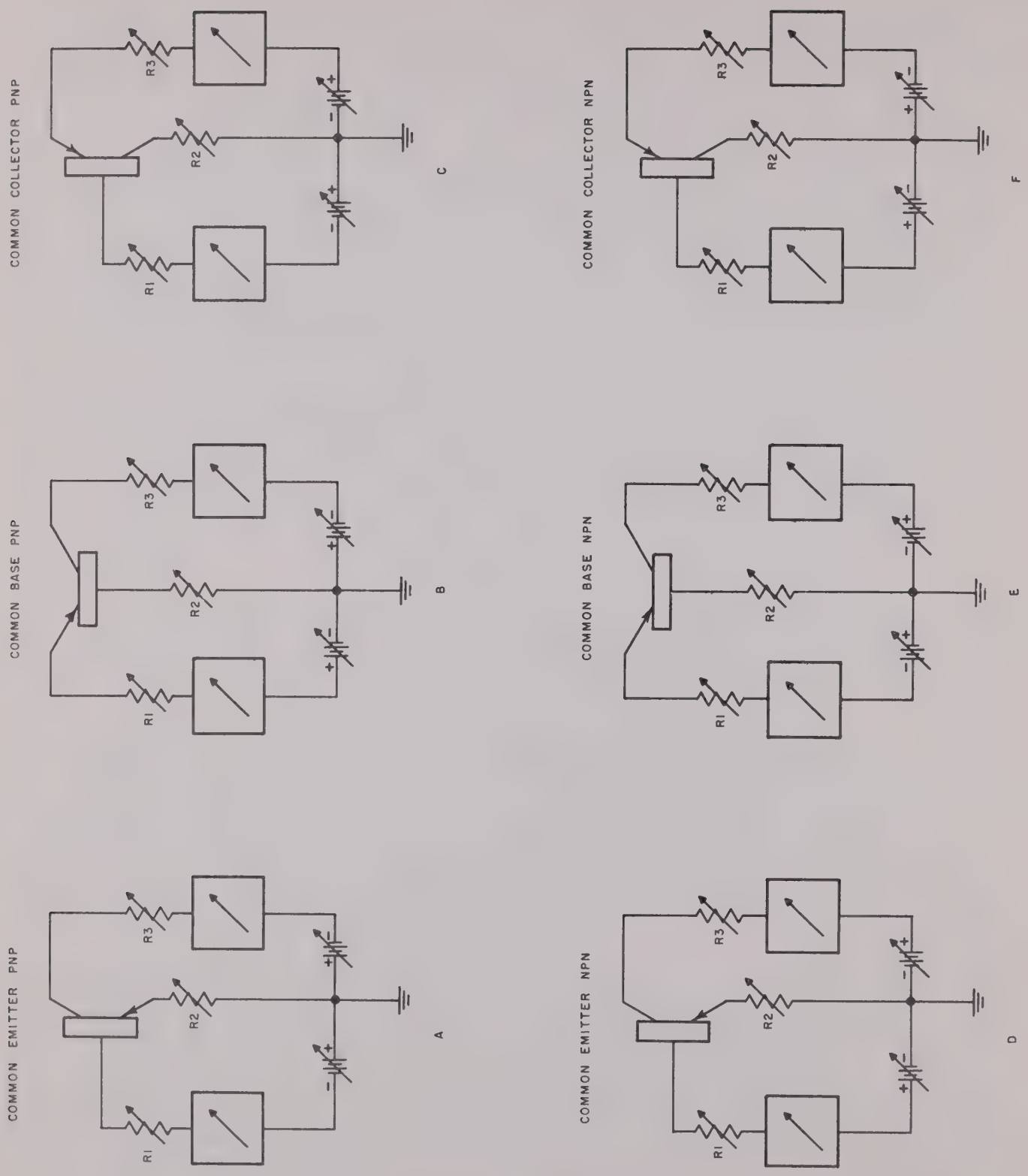


Fig. 1. Illustrates six basic circuits employed in the Transistor Analyzer.

Iceo is known as collector to emitter leakage or collector cutoff current when the collector is reverse biased and the base is open circuited. Figure 3 shows a test set up for checking Iceo under these conditions.

All transistors have leakage Iceo--some more than others. It is only when Iceo becomes excessive, beyond the limits specified by the manufacturer, that the transistor should be assumed defective.

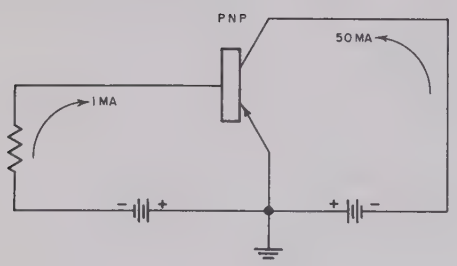


Fig. 2. C. E. configuration with a DC Beta gain of 50.

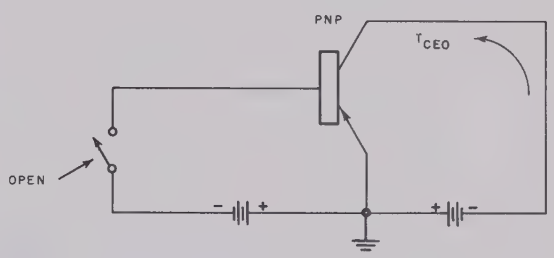


Fig. 3. Illustrates test setup for checking Iceo.

The COMMON EMITTER configuration can also be used as a breadboard to build up amplifiers or oscillators. This configuration, when used for amplifiers, results in high gain. Current gain as high as 200 is possible. Input impedance, 500-100 ohms on the average. The output impedance is approximately 50,000 ohms.

COMMON BASE:

The COMMON BASE circuit of Figure 1-B or 1-E is used to measure Alpha and leakage current Ico, or sometimes termed Icbo. Alpha is the current amplification factor of a transistor when connected in this configuration. AC Alpha is a ratio of a small change in collector current to a small change in emitter current with the collector voltage held constant. DC Alpha is defined as emitter current divided into the collector current or I_c / I_e. For example, referring to Figure 4, one Milliampere of emitter current causes a flow of .96 Milliampere of collector current. This represents a DC Alpha of .96 assuming the leakage current is neglected. Here again the difference between AC Alpha and DC Alpha is small, particularly if AC Alpha is checked at a low frequency and under typical operating conditions.

The value of Alpha is usually near unity. Typical values for a good transistor are .9 to .99. Alpha and Beta are interrelated--if one is known, the other can be

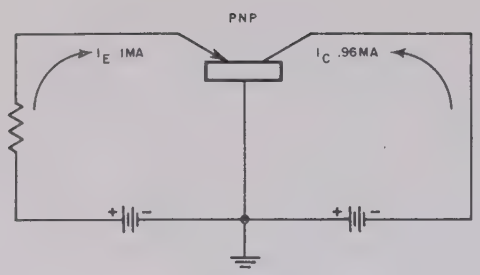


Fig. 4. Shows test setup for checking Alpha

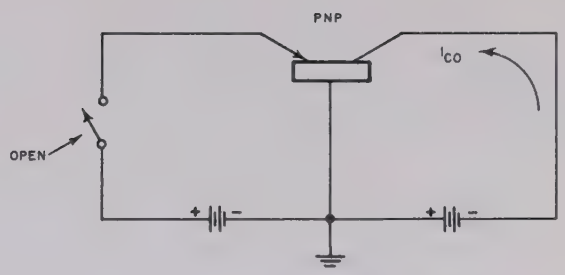


Fig. 5. illustrates test setup for checking Ico

calculated, or vice versa, from the following formulas:

$$B = A / 1-A \quad \text{or} \quad A = B / 1+B \qquad A = \text{Alpha} \qquad B = \text{Beta}$$

Ico or Icbo is the collector to base leakage current with the collector reverse biased and the emitter open circuited. Figure 5 illustrates the test setup for the checking of Ico (Icbo) under these conditions.

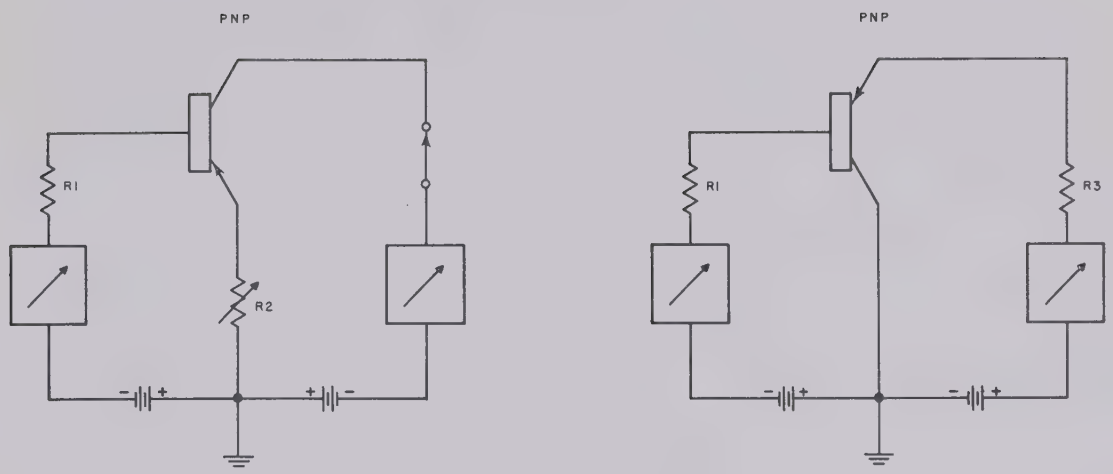
COMMON COLLECTOR:

The COMMON COLLECTOR circuit of Figure 1-C or 1-F is analagous to a cathode follower in vacuum tubes. This configuration is not used for testing transistors as a rule. Some special checks may be performed in the laboratory in this configuration which, however, will not be discussed in this book.

The COMMON COLLECTOR circuitry included in this instrument is intended for breadboard work. Therefore a brief explanation of the COMMON COLLECTOR characteristics will be given.

Figure 6-A and 6-B shows two Common Collector circuits. Figure 6-B is the common collector circuit when the configuration selector is set to the COMMON COLLECTOR position. Figure 6-A is a common collector circuit when the configuration selector is set to the COMMON EMITTER position but R3 is set to zero and R2 is adjusted for resistance in the circuit. The primary difference between these two circuits is the way in which the battery is placed in respsect to the emitter and ground.

In Figure 6-A the emitter is connected through R2 to ground. In Figure 6-B the emitter is connected through R3 in series with a battery to ground. Each circuit has its advantage, depending on how it is used in circuits.



A Fig. 6. Two Common Collector Circuits B

An unusual feature of a common collector circuit is that it can be used as a unity amplifier in either direction. The input signal can be injected in the base and taken out at the emitter, or the input signal can be injected in the emitter and taken out at the base. Now, since the common collector circuit of Figure 6-B has the battery in series with the emitter, that same, only slightly reduced, battery voltage will appear at the base of the transistor because of its conduction in either direction. This voltage can be used as a source of power for a preceding transistor stage.

Figure 6-A, common collector, is best utilized as an emitter follower where a high input impedance and low output impedance are desired.

Listed below are a group of approximate formulas that are useful in the design of common collector transistor circuits:

Input Impedance $\approx (B + 1) R_L$

Output Impedance $\approx R_G (1 - a)$

Voltage Amplification ≈ 1

Current Amplification $\approx (B + 1)$

Power Gain $\approx B + 1$

Where R_L is the emitter follower output load resistor, R_G is the signal source's internal impedance. B is Beta and A is Alpha.

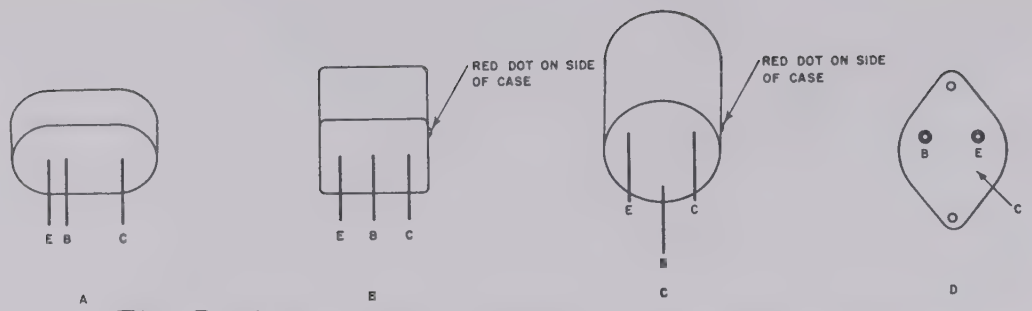


Fig. 7. Bottom view of 4 common types of transistors

Figure 7 illustrates 4 of the most popular types of currently employed radio transistors. The most common type pictured in Figure 7-A has its base and emitter leads closely spaced at one end of the transistor body while the collector is positioned at the other end. Bearing in mind that the center lead is always the base element, the technician should have little trouble in distinguishing between leads on this type of transistor. Connections for units in Figure 7-B and 7-C are determined in a like manner. Figure 7-D pictures a power transistor. The case or outer housing is usually the collector and the base element is located on the left and the emitter on the right.

Battery Installation and Checking Procedure

Before putting the TRANSISTOR ANALYZER into operation, batteries must be installed.

To install batteries, remove battery rack plate. This is accomplished by removing 6 hex head, self-tapping screws on the back side of the case.

Install 10 size D, $1\frac{1}{2}$ volt flashlight batteries into the battery rack. Each battery holder has a polarity sign stamped on it. When installing batteries, special care should be taken to observe polarity. Make certain that each battery is properly seated and is making good electrical contact.

After batteries have been installed, remount battery rack plate to back side of case.

Checking Batteries

To check batteries in the TRANSISTOR ANALYZER the input and output meters are used as voltmeters. Proceed as follows:

1. Set Configuration Selector to COMMON BASE, either NPN or PNP.

2. Set R1 to 27 ohms.

3. Set R2 to zero.

4. Set R3 to 100 ohms.

5. Set INPUT METER RANGE selector to 100 MA.

6. Set VOLTAGE E1 control to zero.

7. Set VOLTAGE E2 control to 12 Volts.

8. Set OUTPUT METER RANGE selector to 1 Amp.

9. With alligator clip leads supplied, short the base to the collector by clipping the base and collector leads together. This completes the voltmeter circuit on the output side of the TRANSISTOR ANALYZER.

10. Depress POWER ON-OFF switch to ON. If batteries are up to full strength the output meter will indicate . 12 Amps or 12 small divisions on the meter scale. If reading is considerably lower, the batteries are weak. Replace the batteries if the meter reading is below 0. 1 Amp. or 10 divisions.

The batteries on the input side, or E1, are checked in the same manner. The base and the emitter are shorted together with the supplied alligator clip leads. The power switch is depressed to ON and held down. The control VOLTAGE E1 is adjusted to maximum clockwise, or 2. 75 volts. The input meter should indicate full scale or 100 divisions if the batteries are up to full strength. A reading of 80 MA is acceptable--below this value the batteries should be replaced.

The 10 batteries contained in this instrument are divided into two sets, E1 and E2. The E1 set consists of two batteries and these are mounted on a vertical plane in the battery rack. Set E2 is made up of 8 batteries and these are mounted in a horizontal plane in the battery rack.

An alternative method of checking the batteries is to use an external voltmeter and measure the battery voltage at points B1 and B2 in reference to the ground binding post.

Testing Transistors

To properly evaluate a transistor, two checks have to be made. An Ico and a Beta check. The Ico or leakage check is made to determine whether a transistor is clean. The smaller the leakage and cleaner the transistor. Clean transistors have longer life because they are relatively free of contaminating materials. It will be found that Silicon Transistors have very low leakage compared to Germanium Transistors. The Ico of Silicon Transistors is usually under 1 Microampere. Ico increases with age and therefore should be checked if a transistor has been in service for a long period of time. A transistor should be replaced if Ico is erratic or much larger than that specified in the transistor manufacturer's literature or the Transistor Reference Chart found in the back of this book.

The next test is a Beta check. This check determines the current amplifying characteristics of a transistor. After Beta is checked it should be compared with the Beta listed in the Transistor Reference Chart. If Beta checked is higher in value than Beta listed, the transistor will have good gain. On the other hand, if the Beta checked is lower than Beta listed, the transistor has lower than average gain.

Testing Transistors for Leakage Ico

1. The first step in testing a transistor is to determine whether the transistor is a PNP or a NPN type. This is accomplished by referring to transistor literature or the Transistor Reference Chart in this book.

2. If transistor leads are clean and free of solder, plug the transistor into the transistor socket, being very careful that the leads are inserted into the proper openings. The openings in the transistor socket are marked E, B, and C, i. e., emitter, base, collector. If the transistor to be checked is a power transistor or if the leads are uneven so that the socket cannot be utilized, the pin jacks and the alligator clip leads should be used. The jacks are also labeled E, B, C, and B_2. Here again special care should be taken to correctly connect the transistor.

   B2 is not used for triode transistors, it is intended for tetrode transistors only Tetrodes usually have four leads and are designated in the Transistor Reference Charts with the number 4 following the type number. For example: NPN-4. Some triode transistors also have four leads. Three of the leads will be E, B, C, and the fourth a ground lead which is usually connected to the body or the case of the Transistor and is intended for shielding purposes only. The ground lead need not be connected to ground while testing.

   CAUTION: If the transistor is not connected properly, damage to the transistor may result.

3. Set CONFIGURATION SELECTOR to COMMON BASE (C. B.) PNP or NPN, depending on the transistor type.

4. Check all binding post connections, make sure all jumpers are in place and binding posts are tight.

5. Set Control R1 to open.

6. Set Control R2 to 0.

7. Set Control R3 to 10K.

8. Input range selector is not used.

9. Control VOLTAGE E1 is not used.

10. Set control VOLTAGE E2 to voltage Vcb listed in the Transistor Reference Chart.

11. The OUTPUT METER RANGE selector is set to desired range to read Ico, usually 100 Microamperes for low and medium power transistors, or 1 MA for power transistors.

12. Depress Power ON-OFF switch to ON and hold down.

    If the transistor is shorted the output meter will indicate full scale. If no short is indicated, step down control R3 to zero resistance and read leakage current Ico on output meter. Compare this reading with Ico listed in the Transistor Reference Chart. If the reading is substantially higher than the listed Ico, the transistor is defective. If the reading is equal or lower, the transistor is good as far as leakage is concerned. The next step is to check Beta to determine the transistor's amplifying characteristic. Proceed with Beta check.

Beta Check

1. Release Power ON-OFF switch to OFF position.

2. Rotate CONFIGURATION SELECTOR to COMMON EMITTER (C. E.) position PNP or NPN, depending on the type of transistor.

3. Adjust the control VOLTAGE E1 to 0 or fully counterclockwise.

4. The control VOLTAGE E2 remains set to the voltage used for leakage check, as specified in the Transistor Reference Chart.

5. Set Control R3 to 10K.

6. Set Control R2 to zero.

7. Set Control R1 to 10K.

8. Set INPUT METER RANGE selector to the 100 Microampere range.

9. Set OUTPUT METER RANGE selector to the 10 Milliampere range.

10. Connect or plug transistor into the transistor socket.

11. Depress POWER ON-OFF switch to ON position and hold down. If the transistor is shorted, one or both meters will deflect to full scale. Release power switch if meters indicate a short. If no short is indicated, step down control R3 to zero.

12. Adjust the control VOLTAGE E1 slowly so that 50 Microamperes of current is circulating in the input circuit. This will cause a current to flow in the output circuit as noted on the output meter. Adjust OUTPUT METER RANGE selector if necessary to get an accurate reading of current flow in the output circuit.

CAUTION: Not more than 5 MA of collector current should be circulated when checking low or medium power transistors. The collector current should not exceed 500 MA when checking power transistors.

Determining Beta

To determine the value of Beta, all that is necessary is to divide the input or base current into the collector current. Beta = I_c / I_b.

For example, if a 50 Microampere base current causes 2 MA of collector current to flow, Beta would equal 40.

For ease of calculation it is desirable to adjust the base current so that it is equal to a power of 10.

For example:

Base current = 100 Microamperes or 10^{-1} MA

Collector current = 4 MA

Beta is equal to 4 MA/ 10^{-1} MA = 4 x 10 = 40

The leakage current, which is a small portion of the collector current, can be neglected in determining Beta.

Beta then should be compared with the Beta listed in the Transistor Reference Chart. If the Beta checked is higher than the Beta listed, the transistor has good gain. On the other hand, if Beta checked is lower than the Beta listed, the transistor has lower than average gain.

An extremely good transistor will show low leakage and high Beta.

Checking AC or Dynamic Beta

AC or Dynamic Beta is defined as a small change of base current divided into the corresponding change of collector current. As a formula

$$\text{AC Beta} = \frac{\triangle I_c}{\triangle I_b}$$

The AC Beta may be very simply measured while the TRANSISTOR ANALYZER is set up for the DC Beta check. To make this measurement, change the base current a small amount, for example, from 50 to 60 Microamperes and note the corresponding change in collector current. If this 10 Microampere change of base current produces a 400 Microampere change of collector current, the AC Beta would equal

$$\text{AC Beta} = \frac{\triangle I_c}{\triangle I_b} = \frac{400}{10} = 40$$

The sign $\triangle$ signifies a small change

Checking Alpha

1. Set CONFIGURATION SELECTOR to COMMON BASE (CB), either NPN or PNP depending on the transistor type. Then connect the transistor.

2. Set R_1 to 100 ohms.

3. Set R_2 to 0.

4. Set R_3 to 100 ohms.

5. Set the Input Meter Range selector to 1 MA for low and medium power transistors and to the 100 MA range for power transistors.

6. The Output Meter Range selector is set to the same position as the Input Meter Range selector.

7. Set Battery Voltage E_1 to zero or fully counterclockwise.

8. Set Battery Voltage E_2 to Voltage listed under the Vcb column of the Transistor Reference Chart.

9. Depress Power ON-OFF switch to ON position and hold it down. If one or both meters deflect to full scale, the transistor is shorted and has to be discarded.

10. If no short is indicated, slowly advance control VOLTAGE E1 until the Input Meter reads exactly 100. The Output Meter will then indicate Alpha directly. For example, if the Output Meter reads 96 then Alpha is equal to . 96. This is assuming that the leakage current, when E1 is set to zero, is negligible. If the leakage is too high to be neglected, the leakage current of the output circuit must be subtracted from the Output Meter reading to obtain the true reading. However, this should not be necessary, for leakage current in this condition will be very low.

Measuring Input Resistance of a Transistor

The Input resistance of a transistor varies greatly depending on the conditions set up in the circuit. The three factors which have a considerable effect on the input resistance are the input current, the output current, and the output load resistance. Therefore it is recommended that this Input Resistance check be made under typical operating voltages and currents as recommended by the transistor manufacturer's specifications.

The transistor under test is set up for either COMMON BASE or COMMON EMITTER, as it is used in a typical circuit. A sensitive voltmeter is connected between binding posts B1 and ground to monitor the voltage E1. The input current flow as read on the input meter is noted. The voltage as read on the external voltmeter is also noted. The VOLTAGE E1 control is then adjusted to cause a

small increase in the voltmeter reading. This will cause a corresponding change in input current. The input resistance is then determined by dividing the small change of input current into the small change of input voltage.

$$R_{(input)} = \frac{\triangle E \text{ (input)}}{\triangle I \text{ (input)}}$$

R = Resistance in ohms

$\triangle E$ = Small change of voltage in volts

$\triangle I$ = Small change of current in amperes

For example:

If the input current changed 50 microamperes with an input voltage change of .05 volts, the input resistance will equal

$$\frac{\triangle E}{\triangle I} = \frac{.05}{.00005} = 1000\ \Omega$$

It is interesting to note that the Input Resistance of a Common Emitter is much higher than that of a Common Base circuit. The difference on the average is about 10 times, where a Common Emitter Input Resistance is 1000 ohms in Common Base it would be down to 100 ohms.

Measurement of Output Resistance

The output resistance of a transistor is measured in the same manner as the input resistance.

The transistor is set up in the TRANSISTOR ANALYZER as a common emitter or common base circuit.

1. R1 - R2 - R3 are set to zero.
2. The VOLTAGE E2 control is set to 12 volts.
3. The meter range selectors are set to the desired range.
4. The VOLTAGE E1 control is set to zero.
5. POWER ON-OFF switch is depressed and held down.
6. The VOLTAGE E1 control is adjusted for normal operating currents in the input and output circuits as specified by the transistor manufacturer's literature.
7. Note the collector current flowing in the output circuit.
8. Decrease battery voltage E2 to 6 volts and note the corresponding change in collector current.

To determine the output resistance merely divide the small change of the collector current into the change of collector voltage or $R_{(output)} = \frac{E\ (output)}{I\ (output)}$

Let's say that with a collector voltage of 12 volts the collector current was .5 Milliamperes and with a collector voltage of 6 volts the collector current decreased to .4 Milliamperes. This represents a change of .1 Milliampere of collector current with a 6 volt change of collector voltage. Therefore,

$$R_{out} = \frac{6V}{.1MA} = \frac{6}{.0001} = 60,000 \text{ ohms}$$

It might be of interest to note that the output resistance of a common base circuit is high, comparable to a pentode in vacuum tubes; whereas a common emitter circuit has a much lower output resistance and is comparable to triodes.

Measurement of Power Gain

To correctly measure power gain of a transistor, the following conditions have to be met.

1. The source resistance must match or equal the input resistance of the transistor.

2. The load resistance must match or equal the output resistance of the transistor.

The input and output resistance of the transistor under test must be determined. This can be done by measurement, using the TRANSISTOR ANALYZER, or by referring to the transistor manufacturer's specifications. Once these parameters are known, R1 can be adjusted to equal the input resistance and R3 adjusted to equal the output resistance.

If the controls R1 and R3 do not include the correct values of resistance, the controls can be switched to the zero position and the proper value of resistance can be inserted in between the input and output binding posts respectively.

Control R2 should be set to zero. The transistor is connected to or plugged into its socket and the POWER ON-OFF switch is depressed to ON. The battery voltages E1 and E2 are adjusted for typical operating conditions. The meter range selectors are set to the desired range and the meter resistance is noted. This should be included as a part of the source resistance in the input circuit. The same applies to the output circuit.

The power gain of a transistor is defined as the input power divided into the output power. Since the input current and the input resistance are known, the input power is equal to I^2R_S. The output power is found in the same manner, I^2R_L. The power gain in D.B. is

$$\text{Power Gain} = 10 \log_{10} \frac{I^2_{out} R_L}{I^2_{in} R_S}$$

R_L is the load resistance and R_S is the source resistance.

Using the TRANSISTOR ANALYZER in Circuit Design

The TRANSISTOR ANALYZER is an excellent instrument for breadboard design. The circuitry desired is automatically set up by merely rotating the CONFIGURATION SELECTOR. The battery polarities are always correct and all parameters are made variable. All tie points are accessible from the front panel. The circuitry inscribed into the front panel offers the operator a direct view of the actual circuit.

The TRANSISTOR ANALYZER is usable up to 5 MC which is certainly more than adequate for most all transistor work.

Figures 8 to 10 illustrate how typical circuits can be breadboarded using the Analyzer.

Maintenance

The Model 850 TRANSISTOR ANALYZER should give long uninterrupted, trouble-free service. Other than an occasional battery change, no electrical repair should be required. Should the instrument become damaged and parts needed, please contact one of our authorized service stations in your locality or The Hickok Electrical Instrument Company Service Department, 10514 Dupont Ave., Cleveland 8, Ohio

Transistor Reference Chart

The Transistor Reference Chart is to be used as a guide in evaluating the quality of transistors. In an effort to simplify the Chart as much as possible, only the pertinent information necessary for testing is given. For any additional information the transistor manufacturer's literature should be consulted.

The data listed in the Transistor Reference Chart has been compiled from various sources, and due to lack of standardization of transistors, it was necessary in some instances to average the data obtained. Therefore, in some cases very small discrepancies may exist. In these cases the transistor manufacturer's specifications should be consulted. However, in general, the data listed is very accurate and can be relied upon in testing transistors.

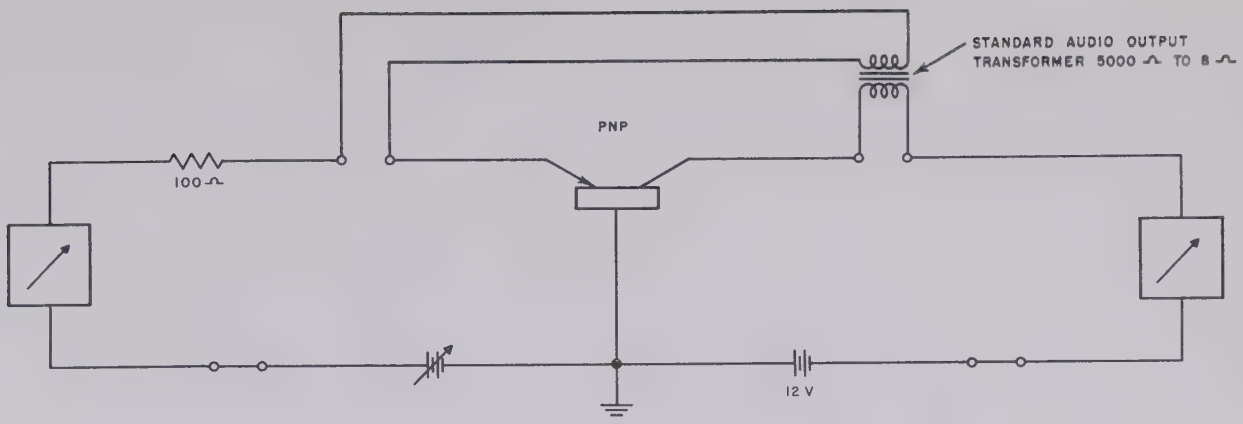


Fig. 8. Audio Oscillator employing a Common Base Circuit.

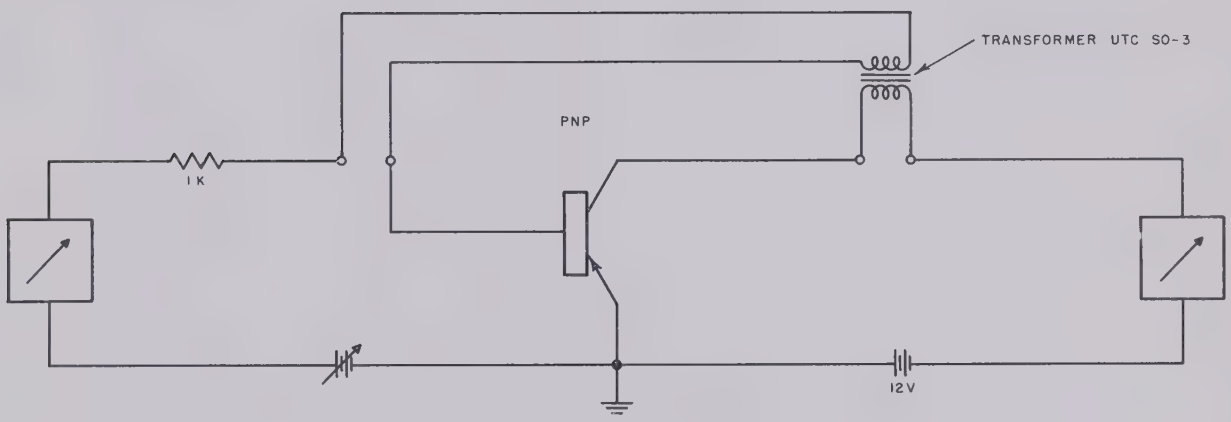


Fig. 9. Audio Oscillator Employing a Common Emitter circuit.

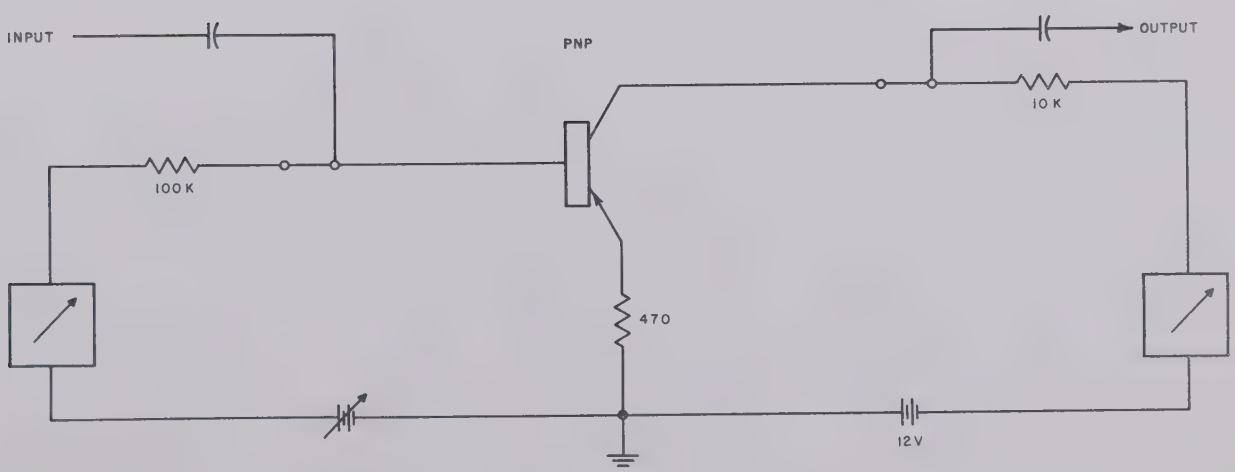


Fig. 10. A typical Audio Amplifier utilizing a Common Emitter configuration.

TRANSISTOR REFERENCE CHART
Measurements Made at 25°C

	Type	Beta	Ico	Vcb		Type	Beta	Ico	Vcb
2N29	NPN	49	2.9μA	12	2N106	PNP	25	12μA	1.5
2N34	PNP	40	2.9μA	12	2N107	PNP	49	10 μA	4.5
2N35	NPN	40	2.9μA	12	2N109	PNP	70	7.5μA	12
2N36	PNP	45	10μA	12	2N109/	PNP	70	4.5μA	10.5
2N37	PNP	30	15μA	12	2N217 EQ				
2N38	PNP	15	25μA	12	2N111	PNP	40	1.0μA	6
2N43	PNP	50	10μA	4.5	2N112	PNP	40	1.0μA	6
2N43A	PNP	32	6μA	12	2N113	PNP	45	1.0μA	6
2N44	PNP	22	10μA	4.5	2N114	PNP	65	1.0μA	6
2N44A	PNP	31	2.5μA	12	2N115	PNP	45	20μA	7.5
2N45	PNP	12	10μA	4.5	2N117	NPN	12	.1μA	12
2N59	PNP	110	7μA	12	2N118	NPN	24	.1μA	12
2N60	PNP	90	7.6μA	10.5	2N118A	NPN	40	7.5μA	12
2N61	PNP	70	7.6μA	10.5	2N119	NPN	50	.07μA	12
2N63	PNP	22	6μA	6	2N120	NPN	71	1.4μA	12
2N64	PNP	45	6μA	6	2N123	PNP	49	1.6μA	10.5
2N65	PNP	90	6μA	6	2N125	NPN	36	1.8μA	4.5
2N66	PNP	25	.2MA	12	2N126	NPN	74	1.8μA	4.5
2N68	PNP	40	.1MA	12	2N128	PNP	35	2.8μA	4.5
2N77	PNP	55	10μA	12	2N129	PNP	20	2.8μA	4.5
2N78	NPN	50	.75μA	7.5	2N130	PNP	22	6μA	6
2N83	PNP	6	100μA	10	2N130A	PNP	22	4.6μA	10.5
2N83A	PNP	8	.06MA	12	2N131	PNP	45	6μA	6
2N84	PNP	6	.1MA	10	2N131A	PNP	45	4.6μA	10.5
2N84A	PNP	12	.067MA	12	2N132	PNP	90	6μA	6
2N85	PNP	40	10μA	12	2N132A	PNP	90	4.6μA	10.5
2N86	PNP	20	10μA	12	2N133	PNP	25	12μA	1.5
2N87	PNP	20	10μA	12	2N133A	PNP	50	4.6μA	10.5
2N88	PNP	35	10μA	12	2N135	PNP	20	5μA	6
2N89	PNP	35	10μA	12	2N136	PNP	40	5μA	6
2N90	PNP	50	10μA	12	2N137	PNP	60	5μA	6
2N91	PNP	40	15μA	6	2N138	PNP	140	6μA	6
2N92	PNP	50	10μA	6	2N139	PNP	45	6μA	12
2N94	NPN	30	3.1μA	10.5	2N140	PNP	48	6μA	12
2N94A	NPN	30	3.1μA	10.5	2N141	PNP	12	.75MA	10.5
2N95	NPN	40	.1MA	10.5	2N142	NPN	12	.75MA	10.5
2N97	NPN	13	2μA	4.5	2N143	PNP	40	.75MA	10.5
2N97A	NPN	13	2μA	4.5	2N144	NPN	40	.75MA	10.5
2N98	NPN	40	2μA	4.5	2N145	NPN	10	.20μA	9
2N98A	NPN	40	2μA	4.5	2N146	NPN	15	.20μA	9
2N99	NPN	40	2μA	4.5	2N147	NPN	15	.20μA	9
2N101	PNP	40	.11MA	10.5	2N155	PNP	32	.6MA	12
2N102	NPN	40	.105MA	10.5	2N156	PNP	40	.126MA	12
2N103	NPN	4.0	5μA	4.5	2N157	PNP	20	.45MA	12
2N104	PNP	44	10μA	12	2N157A	PNP	20	.37MA	12
2N105	PNP	55	5μA	12	2N158	PNP	29	.45MA	12

	Type	Beta	Ico	Vcb
2N158A	PNP	21	.37MA	10
2N160	NPN	13	2.5μA	10
2N160A	NPN	13	2.5μA	10
2N161	NPN	28	2.5μA	10
2N161A	NPN	28	2.5μA	10
2N162	NPN	39	2.5μA	10
2N162A	NPN	39	2.5μA	10
2N163	NPN	49	2.5μA	10
2N163A	NPN	49	2.5μA	10
2N164A	NPN	40	3.5μA	7.5
2N165	NPN	72	3.5μA	7.5
2N167	NPN	25	0.6μA	7.5
2N168	NPN	20	5μA	12
2N168A	NPN	23	.45μA	4.5
2N169	NPN	72	.45μA	4.5
2N169A	NPN	30	.45μA	4.5
2N170	NPN	20	2.9μA	4.5
2N172	NPN	15	.2μA	9
2N173	PNP	50	.26MA	10.5
2N174	PNP	40	.35MA	7.5
2N174A	PNP	25	7.6MA	10.5
2N175	PNP	65	8.5μA	12
2N176	PNP	30	1.4MA	7.5
2N178	PNP	15	1.4MA	7.5
2N180	PNP	60	5μA	7.5
2N181	PNP	60	5μA	7.5
2N182	NPN	24	3μA	10
2N183	NPN	39	3μA	10
2N184	NPN	56	3μA	10
2N185	PNP	55	5.7μA	10.5
2N186	PNP	24	11μA	12
2N186A	PNP	24	11μA	12
2N187	PNP	36	11μA	12
2N187A	PNP	36	11μA	12
2N188	PNP	54	11μA	12
2N188A	PNP	54	11μA	12
2N189	PNP	24	11μA	12
2N190	PNP	36	11μA	12
2N191	PNP	54	11μA	12
2N192	PNP	75	11μA	12
2N193	NPN	6	5μA	6
2N194	NPN	8	5μA	6
2N195	PNP	100	10μA	12
2N196	PNP	50	10μA	12
2N197	PNP	40	10μA	12
2N198	PNP	30	10μA	12
2N199	PNP	15	10μA	12
2N200	PNP	30	10μA	12
2N204	PNP	50	10μA	12
2N205	PNP	15	10μA	12
2N206	PNP	13	8.5μA	12
2N207	PNP	100	15μA	12
2N207A	PNP	100	10μA	12
2N207B	PNP	100	10μA	12
2N211	NPN	30	7μA	6
2N212	NPN	10	8μA	7.5
2N213	NPN	150	.105MA	10.5
2N214	NPN	70	.105MA	10.5
2N215	PNP	44	10μA	12
2N216	NPN	8	10μA	9
2N217	PNP	70	7.5μA	12
2N218	PNP	45	6μA	12
2N219	PNP	48	6μA	12
2N220	PNP	65	8.5μA	12
2N223	PNP	86	20μA	9
2N224	PNP	65	25μA	12
2N225	PNP	65	25μA	12
2N226	PNP	35	25μA	12
2N227	PNP	35	25μA	12
2N228	NPN	70	10μA	4.5
2N229	NPN	24	.19MA	4.5
2N233	NPN	4.5	10μA	6
2N233A	NPN	5	10.6μA	7.5
2N234	PNP	50	.36Amp.	12
2N234A	PNP	50	.36Amp.	12
2N235A	PNP	35	.20MA	12
2N236A	PNP	30	.39Amp.	10.5
2N238/310	PNP	35	5.7μA	10.5
2N240	PNP	20	2.9μA	4.5
2N241	PNP	73	12μA	12
2N241A	PNP	73	12μA	12
2N242	PNP	40	2.5μA	12
2N243	NPN	12	.6μA	12
2N244	NPN	13	.6μA	12
2N247	PNP	60	10μA	1.5
2N248	PNP	20	5μA	12
2N250	PNP	30	.6μA	12
2N251	PNP	30	1.0μA	12
2N252	PNP	30	5μA	12
2N253	NPN	10	.2μA	9
2N254	NPN	15	.2μA	9
2N255	PNP	30	.17MA	12
2N256	PNP	30	.12MA	12
2N257	PNP	60	1MA	10.5
2N265	PNP	110	11μA	12
2N268	PNP	60	.72MA	10.5
2N269	PNP	40	4μA	12
2N270	PNP	70	6.8μA	12
2N274	PNP	60	16μA	12
2N277	PNP	50	360MA	12
2N278	PNP	50	360MA	10.5
2N279/OC70	PNP	30	5μA	4.5
2N280/OC71	PNP	30	4.5μA	4.5
2N281/OC72	PNP	70	4.7μA	10.5

	Type	Beta	Ico	Vcb
2N282/ 2-OC72	PNP	70	4.7μA	10.5
2N283/ OC73	PNP	40	2.7μA	12
2N284/ OC76	PNP	22	4.7μA	10.5
2N284A/ OC77	PNP	22	4.7μA	10.5
2N285A	PNP	30	.26MA	10.5
2N291	PNP	45	6.9μA	12
2N292	NPN	25	.45μA	4.5
2N293	NPN	25	.45μA	4.5
2N296	PNP	19	.105MA	12
2N297	PNP	25	.14MA	12
2N299	PNP	17	2.9μA	4.5
2N300	PNP	17	2.9μA	4.5
2N301	PNP	70	.22MA	12
2N301A	PNP	70	.22MA	12
2N306	NPN	24	.142MA	10.5
2N307	PNP	20	7.6MA	9
2N307A	PNP	20	3.6MA	9
2N308	PNP	30	5μA	9
2N309	PNP	30	5μA	9
2N310	PNP	30	5μA	9
2N311	PNP	50	55μA	12
2N312	NPN	50	55μA	12
2N313	NPN	25	.50μA	4.5
2N314	NPN	25	.50μA	4.5
2N315	PNP	20	1.0μA	4.5
2N316	PNP	30	1.0μA	4.5
2N317	PNP	30	1.0μA	4.5
2N318	PNP	100	15μA	4.5
2N319	PNP	36	11μA	12
2N320	PNP	54	11μA	12
2N321	PNP	73	11μA	12
2N322	PNP	36	11μA	12
2N323	PNP	54	11μA	12
2N324	PNP	75	11μA	12
2N325	PNP	30	.34MA	12
2N326	NPN	30	.34MA	12
2N327	PNP	14	.0036μA	10.5
2N327A	PNP	14	.0006μA	12
2N328	PNP	24	.0036μA	10.5
2N328A	PNP	25	.0006μA	12
2N329	PNP	50	.0036μA	10.5
2N329A	PNP	50	.00069μA	12
2N330	PNP	30	.0036μA	10.5
2N330A	PNP	18	.00069μA	12
2N332	NPN	12	.69μA	4.5
2N333	NPN	24	.69μA	4.5
2N334	NPN	40	.69μA	4.5
2N335	NPN	50	.69μA	4.5
2N336	NPN	76	2.6μA	12
2N337	NPN	16	.7μA	10.5
2N338	NPN	16	.7μA	10.5
2N339	NPN	16	2.4μA	12
2N340	NPN	16	2.1μA	10.5
2N341	NPN	16	.35μA	12
2N342	NPN	12	.69μA	12
2N343	NPN	13	.69μA	12
2N344/ SB101	PNP	22	2.9μA	4.5
2N345/ SB102	PNP	40	2.9μA	4.5
2N346/ SB103	PNP	10	2.9μA	4.5
2N347	NPN	49	.024μA	12
2N348	NPN	24	.035μA	12
2N349	NPN	19	.15μA	12
2N350	PNP	25	2MA	12
2N351	PNP	25	2MA	12
2N352	PNP	30	5MA	1.0
2N353	PNP	40	5MA	1.0
2N356	NPN	20	4.9μA	4.5
2N357	NPN	30	4.9μA	4.5
2N358	NPN	30	4.9μA	4.5
2N359	PNP	150	7.1μA	10.5
2N360	PNP	100	7.1μA	10.5
2N361	PNP	70	7.1μA	10.5
2N362	PNP	120	7.1μA	10.5
2N363	PNP	50	7.1μA	10.5
2N364/ 200A	NPN	12	.69μA	12
2N365/ 201A	NPN	26	.69μA	12
2N366/ 202A	NPN	65	.69μA	12
2N367/ 300	PNP	15	4.9μA	4.5
2N368/301	PNP	34	4.9μA	4.5
2N369/302	PNP	95	4.9μA	4.5
2N370	PNP	60	20μA	12
2N371	PNP	36	20μA	12
2N372	PNP	60	20μA	12
2N373	PNP	60	8μA	12
2N374	PNP	60	8μA	12
2N375	PNP	35	1.4μA	12
2N376	PNP	35	2MA	12
2N377	NPN	40	4.3μA	10.5
2N378	PNP	35	.2MA	12

	Type	Beta	Ico	Vcb		Type	Beta	Ico	Vcb
2N379	PNP	30	.2MA	12	2N431	NPN	15	.15μA	4.5
2N380	PNP	60	.2MA	12	2N432	NPN	40	.15μA	4.5
2N381	PNP	32	5.4μA	12	2N433	NPN	60	2μA	4.5
2N382	PNP	52	5.4μA	12	2N434	NPN	110	2μA	4.5
2N383	PNP	72	5.4μA	12	2N438	NPN	25	1.05μA	12
2N384	PNP	60	16μA	12	2N439	NPN	35	1.05μA	12
2N385	NPN	60	4.0μA	12	2N440	NPN	65	1.05μA	12
2N386	PNP	20	2.4MA	12	2N441	PNP	33	5.1MA	10.5
2N387	PNP	20	1.6MA	10.5	2N442	PNP	33	4.9MA	12
2N388	NPN	80	4.3μA	10.5	2N443	PNP	33	4.8MA	12
2N389	NPN	10	4.8MA	12	2N444	NPN	15	2.1μA	10.5
2N393	PNP	100	4.9μA	4.5	2N445	NPN	15	2.1μA	10.5
2N394	PNP	85	6.1μA	10.5	2N446	NPN	60	2.1μA	10.5
2N395	PNP	87	5.9μA	12	2N447	NPN	125	2.1μA	10.5
2N396	PNP	90	4.3μA	10.5	2N450	PNP	30	2.0μA	6
2N397	PNP	90	6.1μA	10.5	2N451	NPN	15	7.5MA	9
2N398	PNP	60	11μA	1.5	2N452	NPN	8	18MA	9
2N399	PNP	50	.7MA	12	2N453	NPN	20	12MA	12
2N400	PNP	40	.65MA	10.5	2N454	NPN	8	8MA	9
2N401	PNP	40	.7MA	12	2N456	PNP	130	7.6MA	10.5
2N402	PNP	50	7.1μA	10.5	2N457	PNP	130	.9MA	12
2N403	PNP	30	7.1μA	10.5	2N458	PNP	130	.71MA	10.5
2N404	PNP	40	5μA	12	2N459	PNP	40	.34MA	12
2N405	PNP	35	14μA	12	2N460	PNP	24	7.6μA	12
2N406	PNP	35	14μA	12	2N461	PNP	49	7.6μA	45
2N407	PNP	65	14μA	12	2N462	PNP	45	3.6μA	9
2N408	PNP	65	14μA	12	2N463	PNP	20	.16MA	10.5
2N409	PNP	48	10μA	12	2N464	PNP	22	4.3μA	10.5
2N410	PNP	48	10μA	12	2N465	PNP	45	4.3μA	10.5
2N411	PNP	75	10μA	12	2N466	PNP	90	4.3μA	10.5
2N412	PNP	75	10μA	12	2N467	PNP	180	4.3μA	10.5
2N413	PNP	25	2.0μA	12	2N469	PNP	10	15μA	4.5
2N413A	PNP	25	2.0μA	12	2N470	NPN	10	.005μA	6
2N414	PNP	40	2.0μA	12	2N471	NPN	10	.49μA	12
2N414A	PNP	40	2.0μA	12	2N471A	NPN	10	.49μA	12
2N415	PNP	80	12μA	6	2N472	NPN	10	.005μA	6
2N415A	PNP	80	2.0μA	6	2N473	PNP	50	.005μA	6
2N416	PNP	60	2.0μA	12	2N474	NPN	30	.013μA	12
2N417	PNP	80	2.0μA	12	2N474A	NPN	50	.33μA	12
2N418	PNP	45	.7MA	12	2N475	NPN	30	.019μA	12
2N419	PNP	45	.7MA	12	2N476	NPN	45	.019μA	12
2N420	PNP	45	.76MA	10.5	2N477	NPN	45	.013μA	12
2N421	PNP	45	.76MA	10.5	2N478	NPN	60	.019μA	12
2N422	PNP	50	4.3μA	10.5	2N479	NPN	60	.013μA	12
2N424	NPN	10	4.8MA	12	2N479A	NPN	80	.34μA	12
2N425	PNP	30	4.8MA	12	2N480	NPN	60	.015μA	12
2N426	PNP	40	2.0μA	1.5	2N481	PNP	25	3.0μA	12
2N427	PNP	55	2.0μA	1.5	2N482	PNP	25	3.0μA	12
2N428	PNP	80	2.0μA	1.5	2N483	PNP	40	3.0μA	12
2N430	NPN	15	.15μA	4.5	2N484	PNP	60	3.0μA	12

	Type	Beta	Ico	Vcb
2N485	PNP	40	3.0μA	12
2N486	PNP	60	3.0μA	12
2N495 (T1275)	PNP	18	.001μA	10.5
2N496 (T1276)	PNP	18	.001μA	10.5
2N497	NPN	12	.011MA	12
2N498	NPN	12	.011MA	12
2N501	PNP	50	.75μA	4.5
2N504	PNP	16	10μA	12
2N505	PNP	40	.09μA	12
2N508	PNP	125	11μA	7.5
2N509	PNP	49	3.6μA	10.5
2N515	NPN	7.5	35μA	9
2N516	NPN	7.5	35μA	9
2N517	NPN	7.5	35μA	9
2N518	PNP	60	6.0μA	12
2N519	PNP	25	1.9μA	12
2N520	PNP	40	1.9μA	12
2N251	PNP	70	1.9μA	12
2N522	PNP	120	1.9μA	12
2N523	PNP	200	1.9μA	12
2N524	PNP	35	7μA	12
2N525	PNP	52	7μA	12
2N526	PNP	73	7μA	12
2N527	PNP	91	7μA	12
2N529	PNP	18	4.9μA	4.5
2N530	PNP	23	4.9μA	4.5
2N531	PNP	28	4.9μA	4.5
2N532	PNP	33	4.9μA	4.5
2N533	PNP	38	4.9μA	4.5
2N534	PNP	150	4.9μA	12
2N535	PNP	100	3.0μA	12
2N536	PNP	100	3.0μA	12
2N538	PNP	20	.95MA	12
2N538A	PNP	20	.95MA	12
2N539	PNP	30	.95MA	12
2N539A	PNP	30	.95MA	12
2N540	PNP	45	.1MA	1.5
2N540A	PNP	45	.1MA	1.5
2N541	NPN	80	.02μA	12
2N542	NPN	80	.015μA	12
2N543	NPN	80	.012μA	12
2N544	PNP	60	4.0μA	12
2N545	NPN	25	2.9μA	12
2N546	NPN	25	3.5μA	12
2N547	NPN	20	2.9μA	12
2N548	NPN	20	3.3μA	12
2N549	NPN	20	.74μA	12
2N550	NPN	20	1.0μA	12
2N551	NPN	20	2.9μA	12
2N552	NPN	20	4.0μA	12
2N553	PNP	40	.95MA	12
2N554	PNP	45	3MA	6
2N555	PNP	30	3MA	12
2N556	NPN	15	11μA	10.5
2N557	NPN	15	11μA	10.5
2N558	NPN	20	11μA	7.5
2N560	PNP	49	.04μA	12
2N563	PNP	25	6.μA	10.5
2N564	PNP	25	6.μA	10.5
2N565	PNP	55	5.1μA	10.5
2N566	PNP	55	5.1μA	10.5
2N567	PNP	100	5.1μA	10.5
2N568	PNP	100	5.1μA	10.5
2N569	PNP	150	5.1μA	10.5
2N570	PNP	150	5.1μA	10.5
2N571	PNP	200	5.1μA	10.5
2N572	PNP	200	5.1μA	10.5
2N574	PNP	9	3.1MA	12.5
2N574A	PNP	9	7.1MA	10.5
2N575	PNP	10	3.1MA	12.5
2N575A	PNP	10	7.1MA	10.5
2N576	NPN	20	7.1μA	10.5
2N578	PNP	15	3.0μA	12
2N579	PNP	30	3.0μA	12
2N580	PNP	45	3.0μA	12
2N581	PNP	30	1.5μA	6.0
2N582	PNP	60	3.5μA	12
2N583	PNP	30	1.5μA	6.0
2N584	PNP	60	3.5μA	12
2N585	PNP	40	4.0μA	12
2N586	PNP	30	16μA	7.5
2N587	NPN	20	19μA	10.5
2N591	PNP	70	7μA	1
2N592	PNP	20	5μA	4.5
2N593	PNP	50	5μA	4.5
2N594	NPN	20	5μA	4.5
2N595	NPN	35	5μA	4.5
2N596	NPN	50	5μA	4.5
2N597	PNP	40	18μA	12
2N598	PNP	100	18μA	12
2N599	PNP	120	18μA	12
2N605	PNP	40	10μA	12
2N607	PNP	80	10μA	12
2N609	PNP	90	16μA	10.5
2N610	PNP	70	16μA	10.5
2N611	PNP	50	16μA	10.5
2N612	PNP	40	16μA	10.5
2N613	PNP	60	16μA	10.5

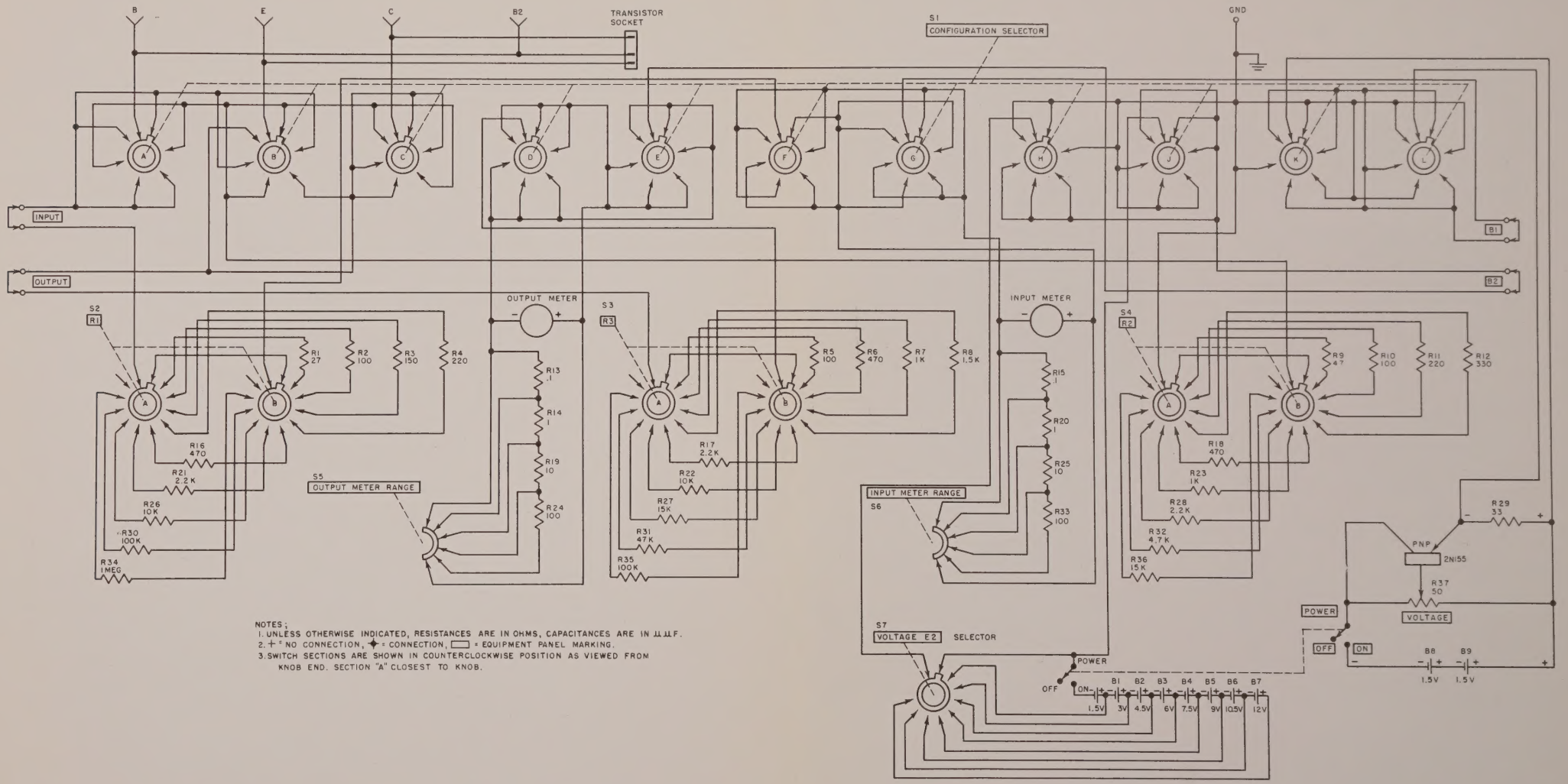
	Type	Beta	Ico	Vcb
2N614	PNP	65	2.2μA	10.5
2N615	PNP	99	2.2μA	10.5
2N616	PNP	65	2.2μA	10.5
2N617	PNP	76	2.2μA	10.5
2N618	PNP	60	1.5μA	12.5
2N619	NPN	14	.005μA	6
2N620	NPN	24	.005μA	6
2N621	NPN	50	.005μA	6
2N622	NPN	22	.005μA	6
2N623	PNP-4	35	1.4μA	10.5
2N627	PNP	10	1.5MA	10.5
2N628	PNP	10	1.4MA	12
2N629	PNP	10	1.1MA	10.5
2N630	PNP	10	1.1MA	12
2N631	NPN	150	10μA	6
2N632	NPN	100	10μA	6
2N633	NPN	70	10μA	6
2N634	NPN	15	4.9μA	4.5
2N635	NPN	25	4.9μA	4.5
2N636	NPN	35	4.9μA	4.5
2N637	PNP	30	.7MA	12
2N637A	PNP	30	2.4MA	12
2N637B	PNP	30	2.4MA	12
2N638	PNP	20	.7MA	12
2N638A	PNP	20	2.4MA	12
2N638B	PNP	20	2.4MA	12
2N639	PNP	15	.7MA	12
2N639A	PNP	15	3.4MA	12
2N639B	PNP	15	3.4MA	12
2T64	NPN	90	10μA	6.0
2T65	NPN	45	10μA	6.0
2T66	NPN	30	10μA	6.0
2T71	NPN	49	8.4μA	12
2T72	NPN	32	8.4μA	12
2T85	NPN	45	10.5μA	12
3N22	NPN-4	50	1.0μA	4.5
3N25/ 501	PNP -4	65	11μA	10.5
3N34	NPN-4	15	.15μA	10.5
3N35	NPN-4	8	.15μA	10.5
3N36	NPN-4	9	3μA	1.5
3N37	NPN-4	13	3μA	1.5
4JD1A17	PNP	40	4.5μA	10.5
4JD1A73	PNP	32	6.0μA	6.0
4JD1B2	PNP	10	16μA	12
4JD1B3	PNP	15	16μA	12
4JD1B4	PNP	15	16μA	12
4JD4A2	NPN	14	.15μA	4.5
4JD4A3	NPN	15	.15μA	4.5
4JD4A4	NPN	15	.15μA	4.5
4JD4A5	NPN	40	.15μA	4.5
204A	NPN	30	7μA	12
355	PNP	30	.6MA	9
903	NPN	12	1.0μA	4.5
904	NPN	24	1.0μA	4.5
904A	NPN	40	1.0μA	4.5
905	NPN	50	1.0μA	4.5
910	NPN-4	76	1.0μA	4.5
951	NPN	16	2.6μA	12
952	NPN	16	2.3μA	10.5
953	NPN	16	3.0μA	12.5
970	NPN	13	.035	12.5
3604	NPN	13	7.0μA	10.5
3607	NPN	32	7.0μA	10.5
3609	NPN	32	7.0μA	10.5
B134	PNP	15	1.4MA	12
B134A	PNP	15	2.5MA	12
B134B	PNP	15	2.5MA	12
CK13	PNP	25	2.0μA	12
CK14	PNP	40	2.0μA	12
CK16	PNP	60	2.0μA	12
CK17	PNP	80	2.0μA	12
CK22	PNP	90	4.5μA	10.5
CK25	PNP	30	1.9μA	12
CK26	PNP	40	1.9μA	12
CK27	PNP	55	1.9μA	12
CK28	PNP	80	1.9μA	12
CK64	PNP	22	4.6μA	10.5
CK65	PNP	45	4.6μA	10.5
CK66	PNP	90	4.6μA	10.5
CK67	PNP	180	4.6μA	10.5
CK721	PNP	45	6μA	6
CK722	PNP	12	6μA	6
CK723	PNP	22	6μA	6
CK725	PNP	90	6μA	6
CK727	PNP	25	12μA	1.5
CK754	PNP	300	3.7μA	10.5
CK790	PNP	9	.15μA	10.5
CK791	PNP	18	.15μA	10.5
CK793	PNP	9	.15μA	10.5
CK870	PNP	12	4.7μA	10.5
CK871	PNP	20	4.7μA	10.5
CTP1032	PNP	13	4.0μA	6.0
CTP1033	PNP	25	4.0μA	6.0
CTP1034	PNP	45	4.0μA	6.0
CTP1035	PNP	65	4.0μA	6.0

	Type	Beta	Ico	Vcb
CTP1036	PNP	85	4.0μA	6.0
CTP1104	PNP	30	1.2MA	10.5
CTP1108	PNP	30	1.6MA	10.5
CTP1109	PNP	60	1.6MA	10.5
CTP1111	PNP	30	.8MA	10.5
CTP1117	PNP	100	1.0MA	10.5
CTP1119	PNP	80	1.0MA	12
CTP1320	PNP	13	4.0μA	6.0
CTP1330	PNP	25	4.0μA	6.0
CTP1340	PNP	45	4.0μA	6.0
CTP1350	PNP	65	4.0μA	6.0
CTP1360	PNP	85	4.0μA	6.0
DT80	PNP	35	5.4MA	10.5
DT100	PNP	39	3.5MA	12
GA52829	PNP	50	3.3μA	10.5
GA52830	PNP	99	10μA	4.5
GA53104	PNP	49	1.9μA	10.5
GA53149	PNP	49	3.3μA	10.5
GA53194	PNP	19	18μA	9.0
GA53233	PNP	3	11μA	10.5
GA53242	PNP	45	.55MA	10.5
GA53270	NPN	49	11μA	12.5
GET3	PNP	50	6.0μA	6.0
GET4	PNP	50	6.0μA	6.0
GET6	PNP	50	6.0μA	6.0
GET7	PNP	20	1.5MA	7.5
GET8	PNP	20	1.1MA	7.5
GET9	PNP	20	1.1MA	12.5
GET15	PNP	55	6.0μA	6.0
GF45017	PNP	45	.06MA	10.5
GFT20	PNP	25	5.0μA	3.0
GFT21	PNP	90	10μA	3.0
GFT4012/30	PNP	50	.105MA	12
GFT4012/60	PNP	50	.075MA	12
GT1	PNP	20	5.0μA	4.5
GT2	PNP	40	5.0μA	4.5
GT3	PNP	60	5.0μA	4.5
GT11	PNP	30	5.0μA	4.5
GT12	PNP	60	5.0μA	4.5
GT13	PNP	100	5.0μA	4.5
GT14	PNP	28	14μA	12
GT14H	PNP	28	10μA	4.5
GT20	PNP	45	14μA	12
GT20H	PNP	42	10μA	4.5
GT34	PNP	15	14μA	12
GT34HV	PNP	18	12μA	12
GT34N	PNP	18	.158MA	12
GT34S	PNP	15	14μA	12
GT35	NPN	40	12μA	12
GT74	PNP	75	7μA	10.5
GT75	PNP	150	7μA	10.5
GT81	PNP	65	14μA	12
GT81H	PNP	80	10μA	4.5
GT81HS	PNP	120	6.3μA	10.5
GT82	PNP	150	7μA	10.5
GT83	PNP	45	14μA	12
GT87	PNP	28	14μA	12
GT88	PNP	80	5.0μA	4.5
GT109	PNP	120	6.0μA	4.5
GT122	PNP	100	5.0μA	4.5
GT123	PNP	90	4.7μA	10.5
GT153	PNP	20	3.7μA	10.5
GT167	NPN	25	8μA	12
GT210H	PNP	120	26μA	10.5
GT222	PNP	20	6.0μA	4.5
GT229	NPN	10	15μA	10.5
GT269	PNP	32	4.0μA	12
GT758	PNP	15	4.8μA	12
GT759	PNP	15	4.8μA	12
GT759R	PNP	25	7.3μA	10.5
GT760	PNP	40	1.0μA	4.5
GT760R	PNP	40	7.2μA	10.5
GT761	PNP	70	1.0μA	4.5
GT761R	PNP	70	7.2μA	10.5
GT762	PNP	150	1.0μA	4.5
GT762R	PNP	150	7.2μA	10.5
GT763	PNP	200	1.0μA	4.5
GT764	PNP	200	4.9μA	12
GT792	NPN	100	5.9μA	4.5
GT903	NPN	53	19μA	10.5
GT904	NPN	30	19μA	10.5
GT905	NPN	30	19μA	10.5
GT905R	NPN	40	6.3μA	10.5
GT947	NPN	40	26μA	10.5
GT948	NPN	30	16μA	10.5
GT949	NPN	30	16μA	12
GT949R	NPN	120	6.3μA	10.5
H3A	PNP	10	.49MA	12
H4A	PNP	23	.49MA	12
H5	PNP	20	.2MA	1.5
H6	PNP	30	.2MA	1.5
H7	PNP	46	.2MA	1.5
H200E	PNP	40	.98MA	12
HA5001	NPN	65	4.9μA	4.5
HA5002	NPN	99	10μA	4.5
HA5003	NPN	27	12μA	4.5
HA5005	NPN	150	30μA	4.5
HA5009	NPN	150	30μA	4.5

	Type	Beta	Ico	Vcb		Type	Beta	Ico	Vcb
HA5011	NPN	25	20μA	4.5	T1050	PNP	45	2.0μA	3
HA5012	NPN	50	20μA	4.5	TF65	PNP	45	30μA	1.0
HA5014	NPN	150	20μA	4.5	TF77	PNP	20	.019MA	4.5
HA5016	NPN	50	5.0μA	4.5	TF77/30	PNP	20	.019MA	4.5
HA5020	NPN	49	5.0μA	4.5	TF80	PNP	25	.095MA	4.5
HA5021	NPN	49	10μA	4.5	TF80/30	PNP	25	.095MA	4.5
HA5022	NPN	49	4.0μA	4.5	TJ1	PNP	10	11μA	10.5
HA7501	PNP	11	.10μA	4.5	TJ2	PNP	30	11μA	10.5
HA7502	PNP	16	.10μA	4.5	TJ3	PNP	50	11μA	10.5
LT51	PNP	30	.33MA	12	TR10	PNP	18	13μA	12
LT52	PNP	45	.175MA	12	TR19	PNP	100	5.0μA	4.5
MA32	PNP	30	1.9MA	12	TR81	PNP	65	11μA	7.5
MN48	PNP	30	3MA	12	TR87	PNP	28	11μA	7.5
OC16	PNP	23	.09MA	12	TR88	PNP	65	11μA	7.5
OC30	PNP	36	7μA	3	TR269	PNP	30	1μA	.15
OC44	PNP	100	9μA	12	TR722	PNP	200	6μA	6 V
OC45	PNP	40	9μA	12	TR760	PNP	40	1μA	6
OC65	PNP	30	5.0μA	4.5	TR761	PNP	75	1μA	6
OC66	PNP	47	5.0μA	4.5	TR762	PNP	100	1μA	6
OC360	PNP	25	6.0μA	4.5	TR763	PNP	120	1μA	6
RD316	NPN	9	.20μA	4.5	TR764	PNP	200	3.8μA	7.5
S500	PNP	18	.0015μA	10.5	TS1	PNP	10	11μA	10.5
S501	PNP	18	.0015μA	10.5	TS2	PNP	30	11μA	10.5
S520	PNP	14	.001μA	6	TS3	PNP	50	11μA	10.5
SB100	PNP	23	.5μA	3.0	TS615	PNP	25	7.5μA	12
ST10	NPN	16	.019μA	12	TS619	PNP	50	5.6μA	12
ST11	PNP	50	.005μA	6	TS620	PNP	50	10.5μA	12
ST12	NPN	60	.019μA	12	TS621	PNP	100	10.5μA	12
ST13	NPN	45	.019μA	12	TS628	PNP	99	6μA	6
ST14	NPN	80	.02μA	12	TS629	PNP	65	6μA	6
ST30	NPN	16	.013μA	12	TS630	PNP	50	7.5μA	12
ST31	NPN	30	.013μA	12	TS637	PNP	20	2.4μA	10.5
ST32	NPN	60	.013μA	12	TS650	PNP	100	10μA	10.5
ST33	NPN	45	.013μA	12	V6/R2	PNP	25	1.0μA	4.5
ST34	NPN	80	.015μA	12	V6/R4	PNP	50	1.0μA	4.5
ST40	NPN	16	.012μA	12	V6/R8	PNP	80	1.0μA	4.5
ST41	NPN	30	.019μA	12	V10/15A	PNP	20	10μA	4.5
ST42	NPN	60	.015μA	12	V10/30A	PNP	40	10μA	4.5
ST44	NPN	80	.012μA	12	V10/30B	PNP	75	10μA	4.5
ST400	NPN	15	10MA	12	V15/10P	PNP	10	.10MA	1.5
ST401	NPN	20	11MA	12	V15/20P	PNP	20	.10MA	1.5
ST402	NPN	15	10MA	12	V15/30P	PNP	30	.10MA	1.5
ST403	NPN	15	11MA	12	V30/10P	PNP	10	.10MA	1.5
ST903	NPN	9	.07μA	12	V30/20P	PNP	20	.10MA	1.5
ST904	NPN	18	.07μA	12	V30/30P	PNP	30	.10MA	1.5
ST904A	NPN	18	.07μA	12	VB701	PNP	80	9.0μA	12
ST905	NPN	36	.07μA	12	VB704	PNP	50	10μA	12
ST910	NPN	76	.07μA	12	VB709	PNP	100	11μA	10.5
T1000	PNP	45	20μA	9	XA101	PNP	35	10μA	12
T1001	PNP	70	20μA	9	XA102	PNP	40	10μA	12

	Type	Beta	Ico	Vcb
XB102	PNP	30	10μA	12
XB103	PNP	67	10μA	12
XC101	PNP	66	7.07μA	7.5
XD5081	PNP	25	.26MA	9
XD5082	PNP	25	.26MA	9
XD5083-4	PNP	20	.26MA	9
XH10	PNP	20	3.5MA	12

ALT	DRAWING NUMBER
	930 W



NOTES;
1. UNLESS OTHERWISE INDICATED, RESISTANCES ARE IN OHMS, CAPACITANCES ARE IN μμF.
2. + = NO CONNECTION, ✦ = CONNECTION, ▭ = EQUIPMENT PANEL MARKING.
3. SWITCH SECTIONS ARE SHOWN IN COUNTERCLOCKWISE POSITION AS VIEWED FROM KNOB END. SECTION "A" CLOSEST TO KNOB.

DRAWING NUMBER
930 W

TRANSISTOR ANALYZER

SCHEMATIC WIRING DIAGRAM - MODEL 850

DRAWN & TRACED	CHECKED	APP'D	DATE
LDD RB	RRC	WR	9-5-58

THE HICKOK ELECTRICAL INSTRUMENT CO.
CLEVELAND, OHIO

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